Components	TPM	RCM
Focus on important machines	no	Yes
Creation of inspection methods for the equipment	no	Yes
Individual determination of the maintenance strategy	no	yes
Tips on the use of diagnostic methods	yes	yes
Creation of spare part management	no	only general tips
Instructions on inclusion of sub-companies	yes	No
Tips for constructive modifications	yes	Yes
Instructions for formation of redundancies	no	Yes
Tips for the speedy replacement of construction groups	yes	Yes
Description of maintenance tasks	Inspection and servicing (not including repairs)	Inspection and servicing (not including repairs)
Tips for increased productivity	no	No
Determination of time needed	no	No
Determination of implementation responsibility	Yes	Yes
Determination of implementation intervals	Yes	Yes
Employee instruction	Yes	yes
Further training for employees	Yes	yes
Adaptation of construction organization	No	No

FIG. 1
(PRIOR ART)

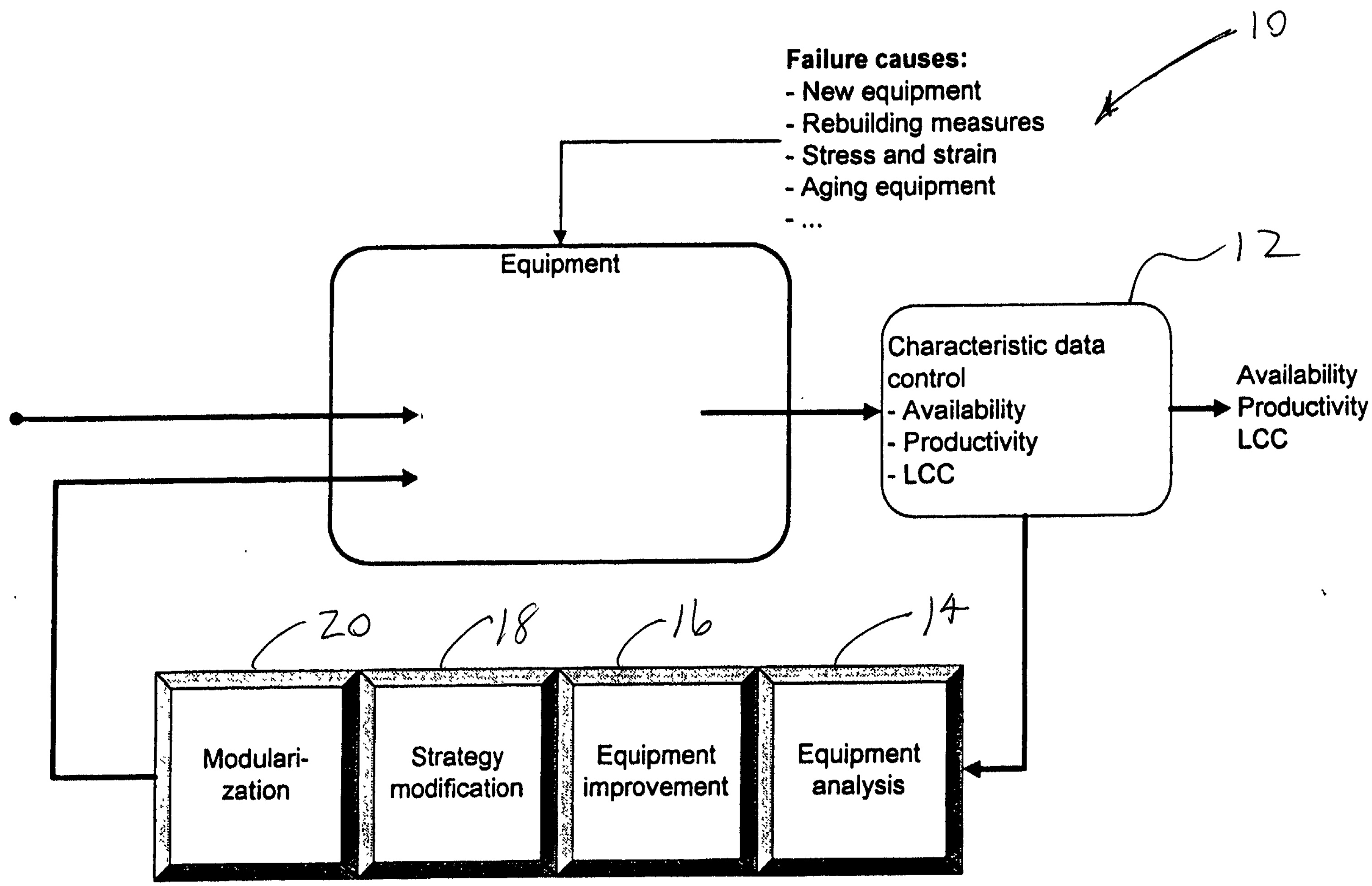

10
Failure causes:
- New equipment
- Rebuilding measures
- Stress and strain
- Aging equipment
- ...
Equipment
12
Characteristic data control
- Availability
- Productivity
- LCC
Availability
Productivity
LCC
20
18
16
14
Modulari-zation
Strategy modification
Equipment improvement
Equipment analysis

FIG. 2

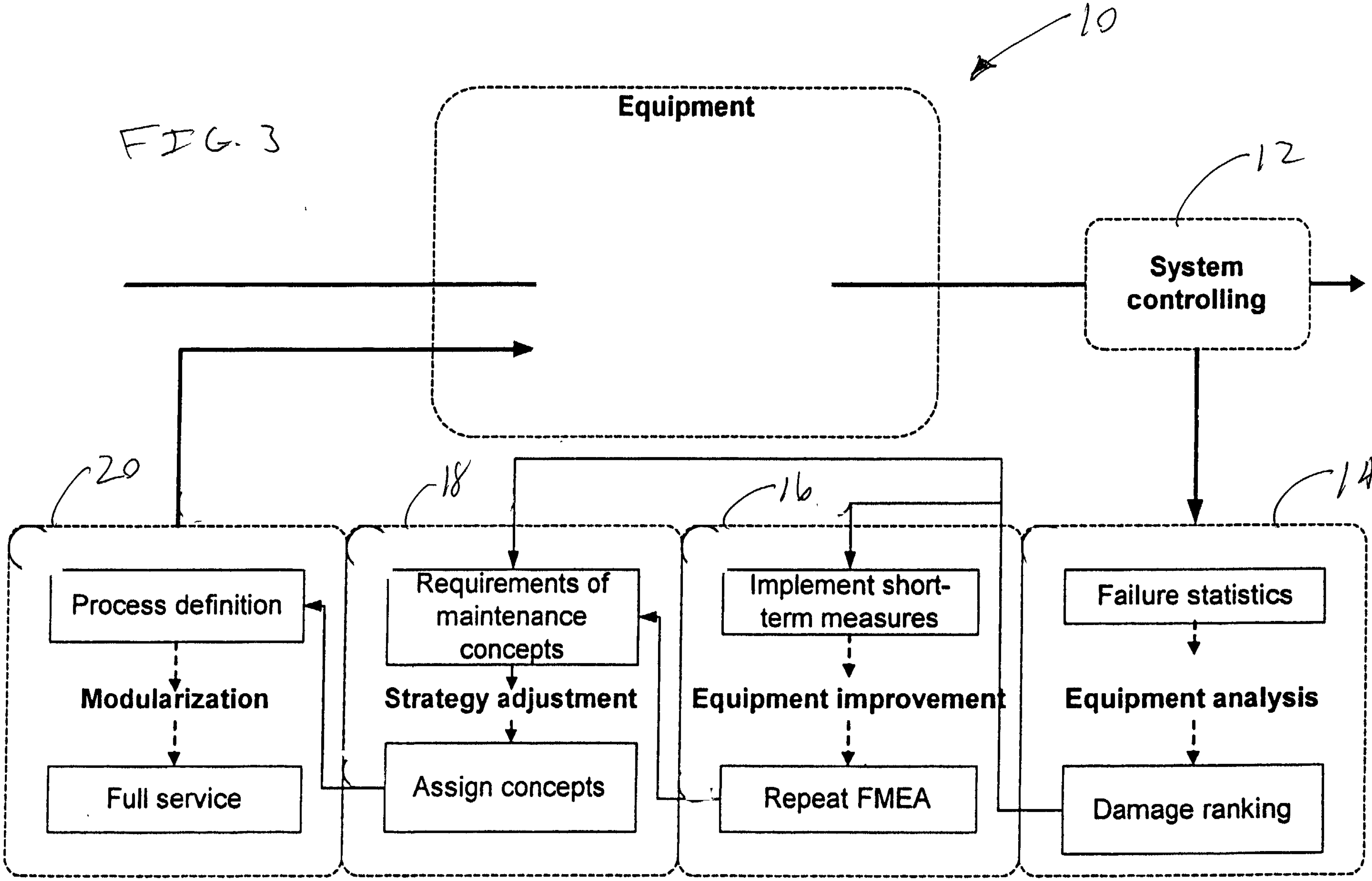

10
Equipment
System controlling
12
20
18
16
14
Process definition
Modularization
Full service
Requirements of maintenance concepts
Strategy adjustment
Assign concepts
Implement short-term measures
Equipment improvement
Repeat FMEA
Failure statistics
Equipment analysis
Damage ranking

FIG. 3

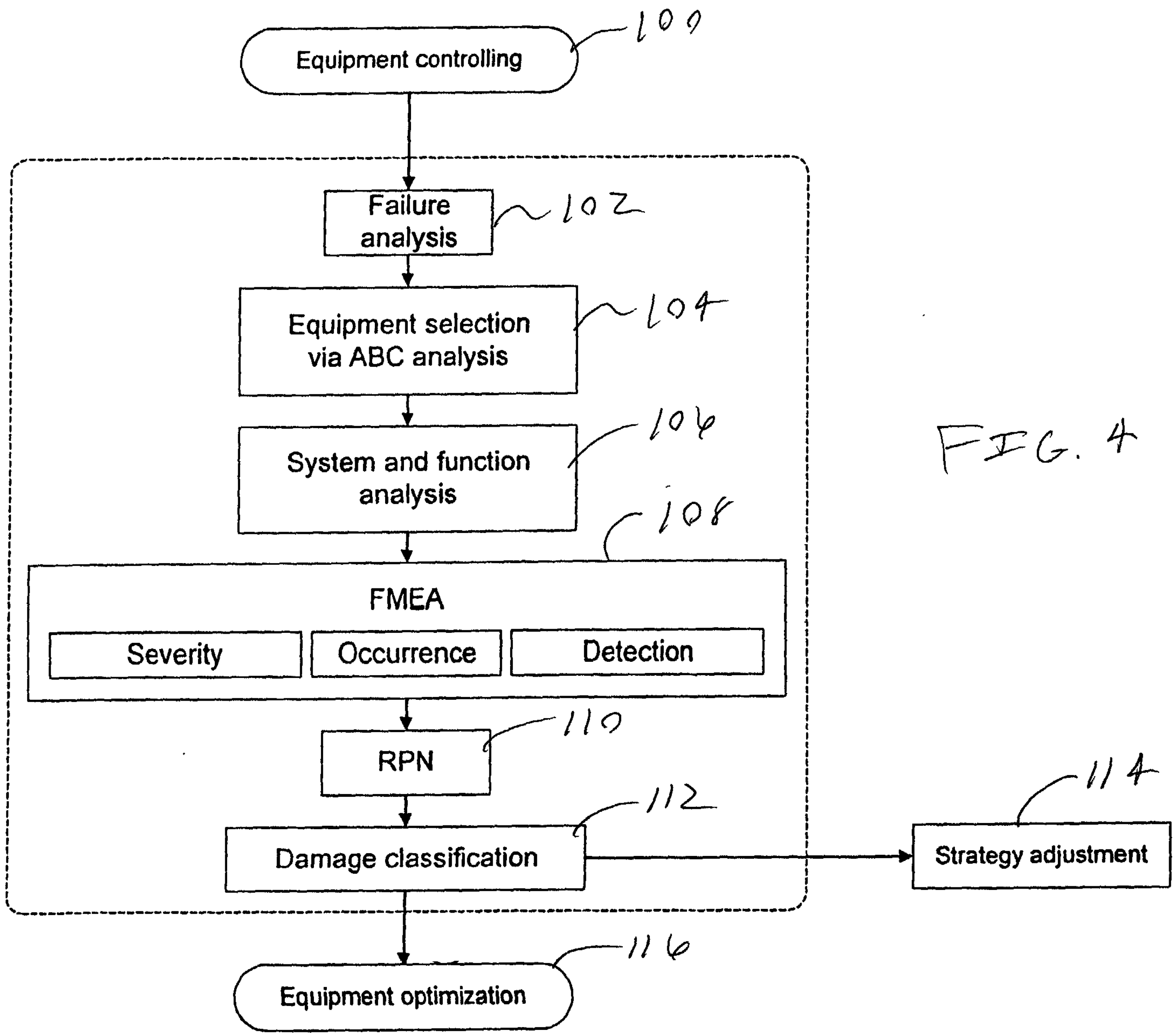

100
Equipment controlling
Failure analysis
102
Equipment selection via ABC analysis
104
System and function analysis
106
108
FMEA
Severity
Occurrence
Detection
RPN
110
Damage classification
112
Strategy adjustment
114
Equipment optimization
116

FIG. 4

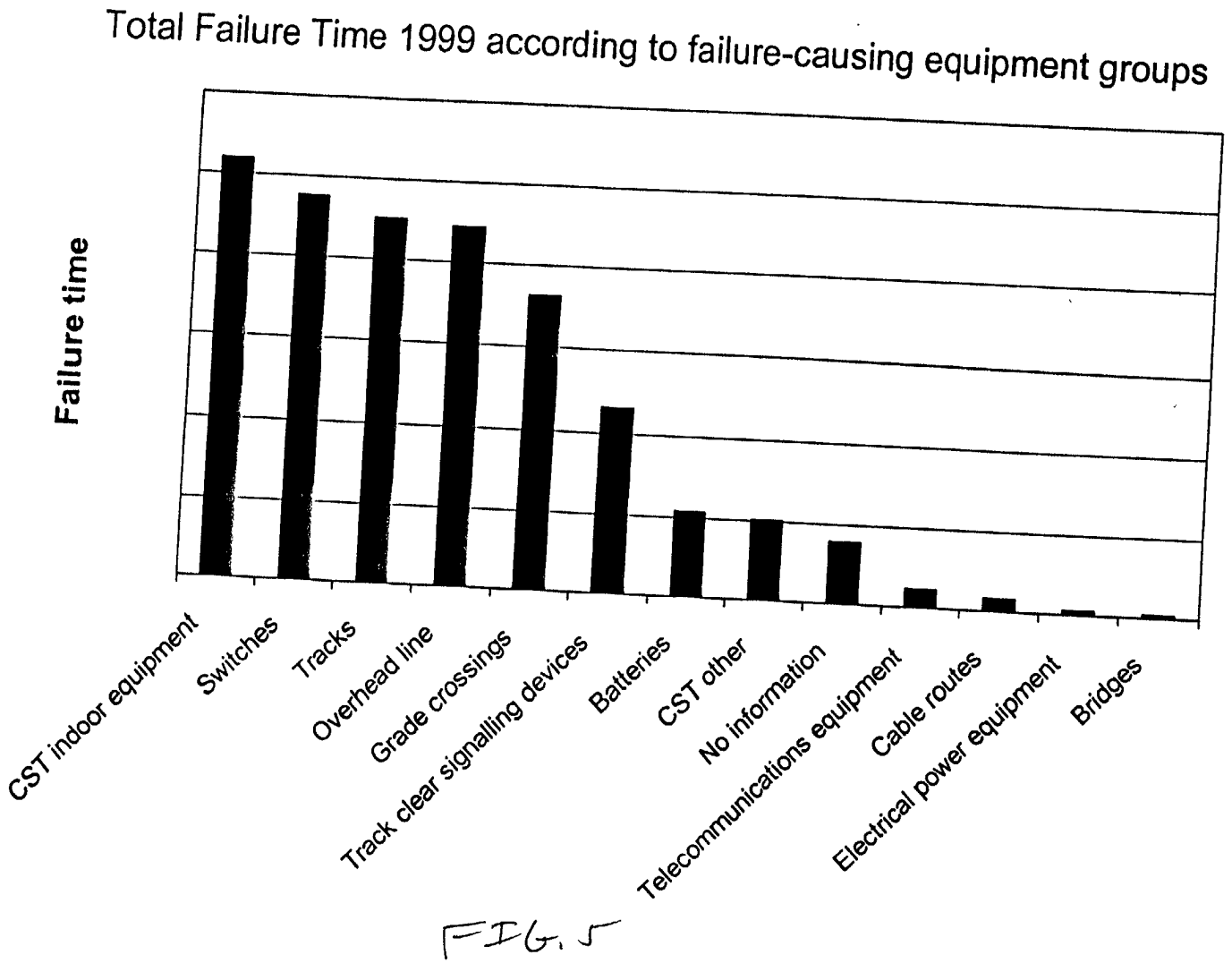

Total Failure Time 1999 according to failure-causing equipment groups
Failure time
CST indoor equipment
Switches
Tracks
Overhead line
Grade crossings
Track clear signalling devices
Batteries
CST other
No information
Telecommunications equipment
Cable routes
Electrical power equipment
Bridges

FIG. 5

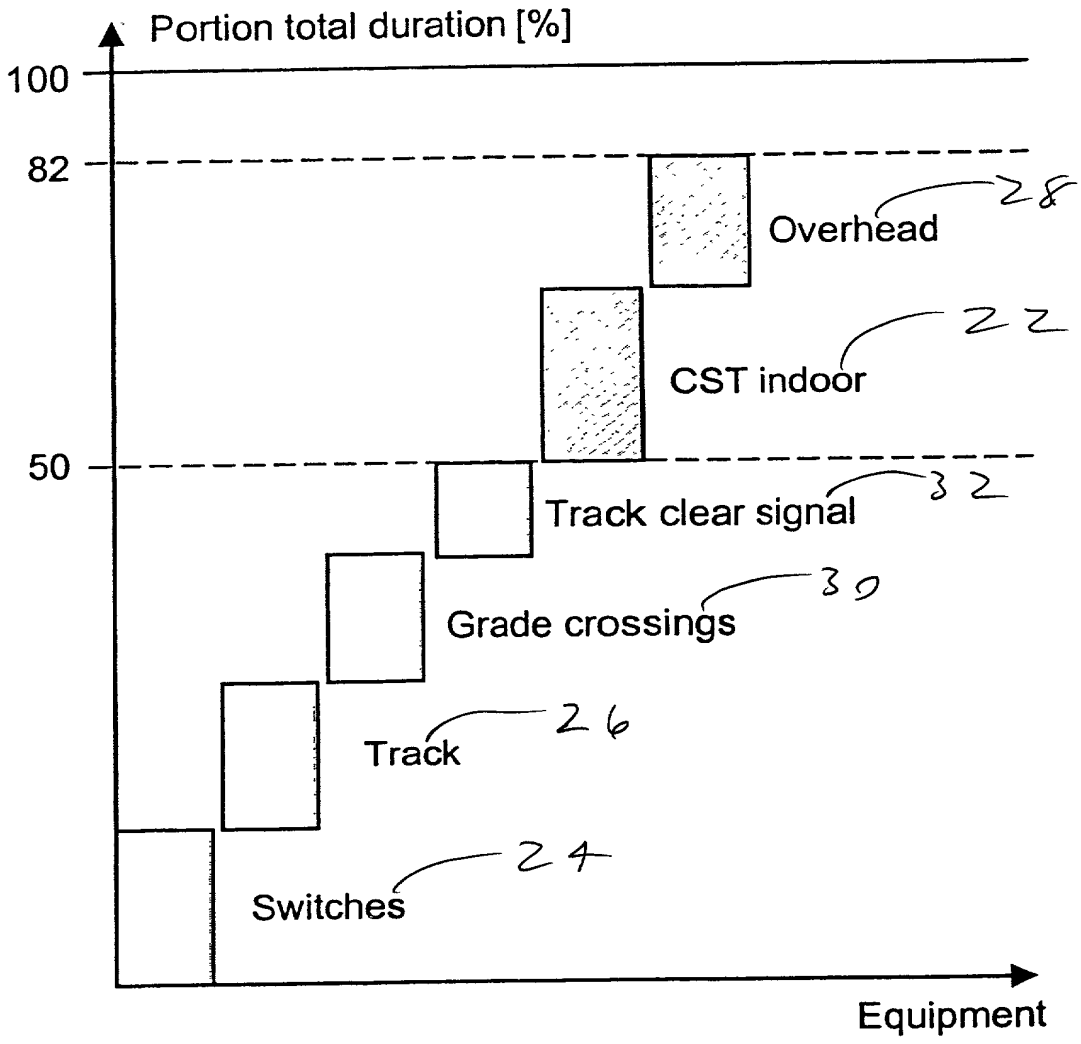

Portion total duration [%]
100
82
50
Overhead
28
CST indoor
22
Track clear signal
32
Grade crossings
30
Track
26
Switches
24
Equipment

FIG. 6

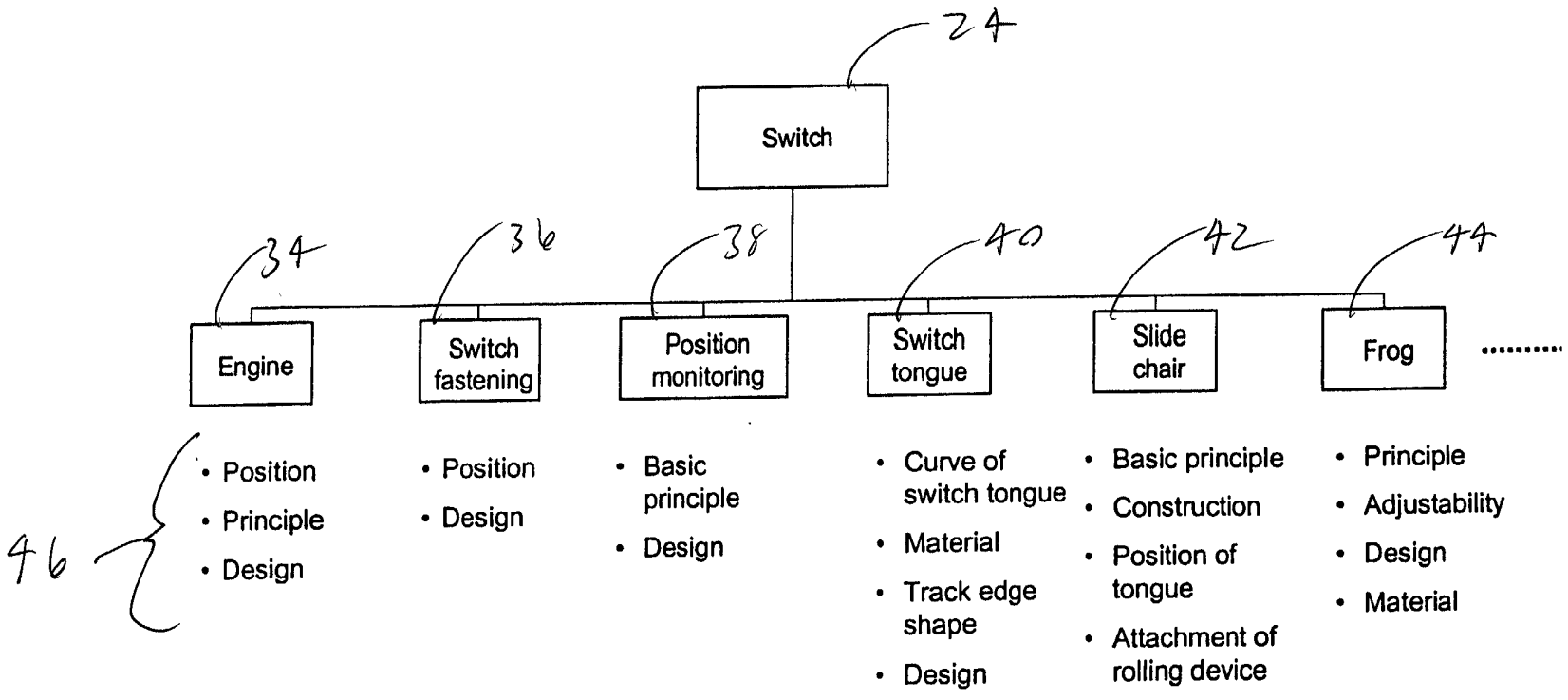


FIG. 7

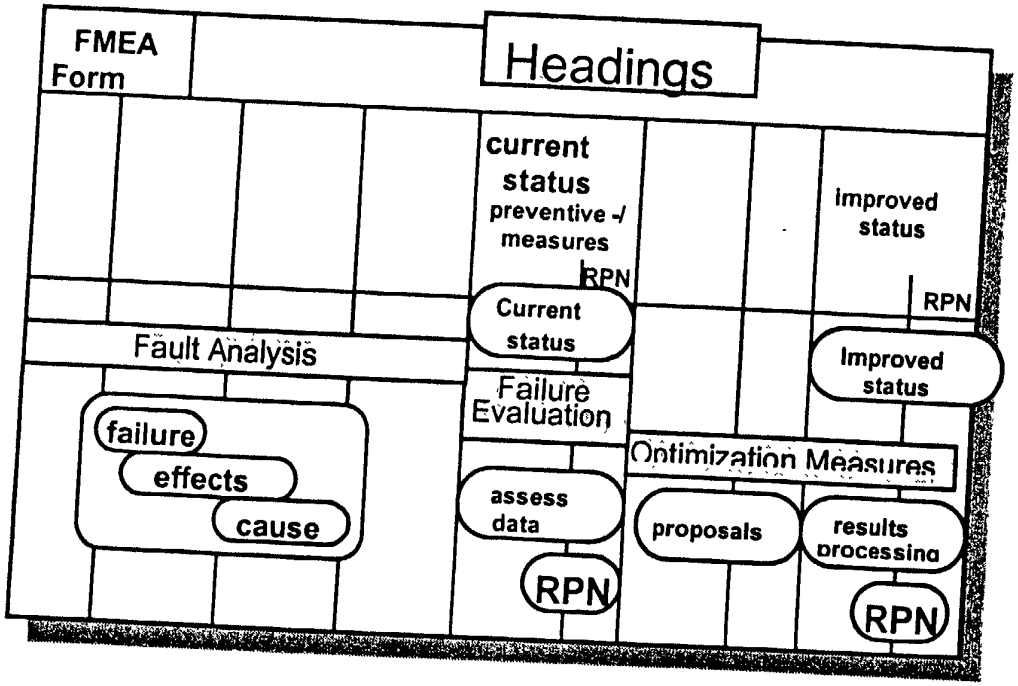


FIG.8

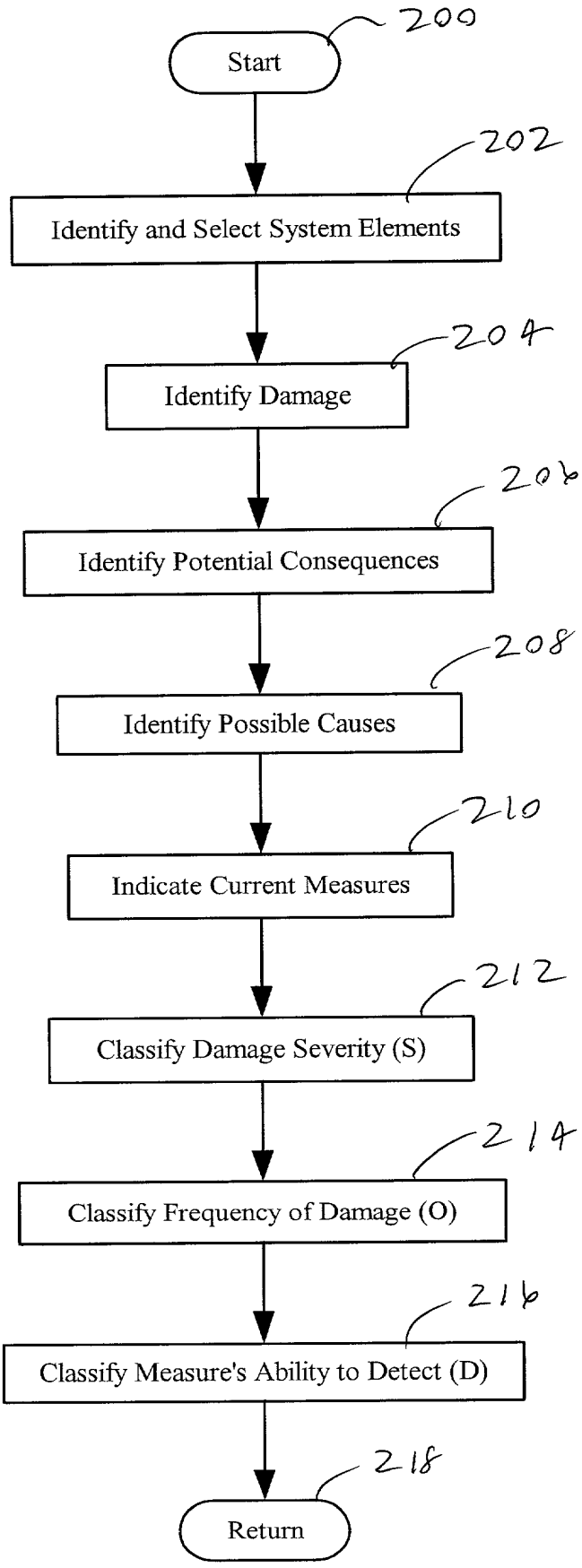

200
Start
202
Identify and Select System Elements
204
Identify Damage
206
Identify Potential Consequences
208
Identify Possible Causes
210
Indicate Current Measures
212
Classify Damage Severity (S)
214
Classify Frequency of Damage (O)
216
Classify Measure's Ability to Detect (D)
218
Return

FIG. 9

Current Damage Cause Evaluation and Classification								
Damage Description	**No.**	**Potential Results**	**S**	**Potential Causes (wear & tear)**	**O**	**Preventive and Inspection Measures**	**D**	**RPN**
Passage groove too small	1	Collision alarm through approaching of switch tongue	4	Bent switch tongue	6	Measurement of passage groove	6	
	2	Broken switch tongue due to running up against switch tongue	9	Assembly defect in control mechanism	3	Acceptance inspection for maintenance work by external companies	7	
	3	Wheels strike the switch tongue (overriding of the rail)	10					

FIG. 10

Current Damage Cause Evaluation and Classification								
Damage Description	No.	Potential Results	S	Potential Causes (wear & tear)	O	Preventative and Inspection Measures	D	RPN
Passage groove too small	1	Collision alarm through approaching of the switch tongue	4	Bent switch tongue	6	Measurement of passage groove	6	360
	2	Broken switch tongue due to running up against the switch tongue	9	Assembly defect in control mechanism	3	Acceptance of the repair by an outside company	7	210
	3	Wheels strike the switch tongue (overriding of rail)	10					

FIG. 11

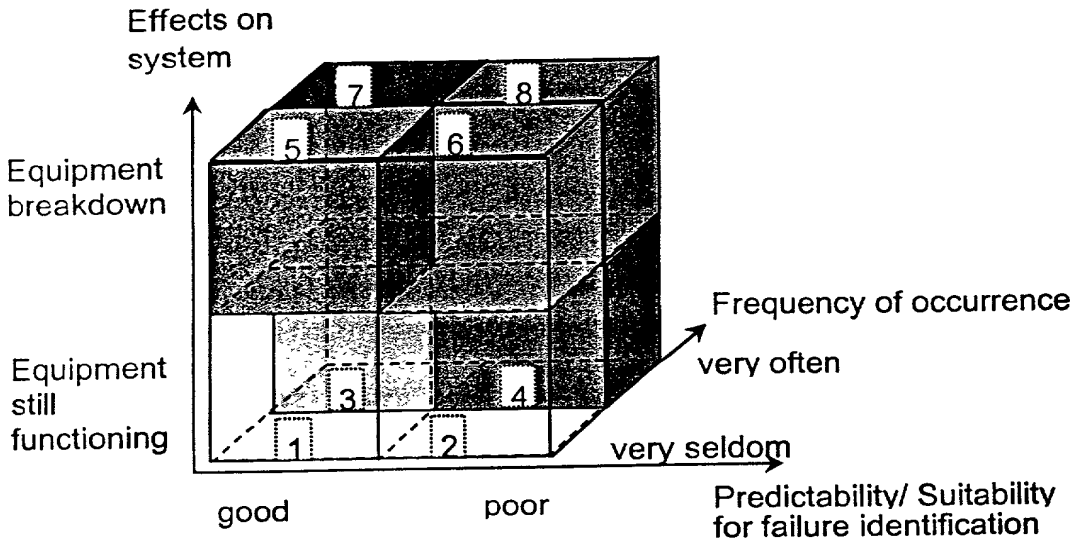

Effects on system
Equipment breakdown
Equipment still functioning
Frequency of occurrence
very often
very seldom
good
poor
Predictability/ Suitability for failure identification
1
2
3
4
5
6
7
8

FIG. 12

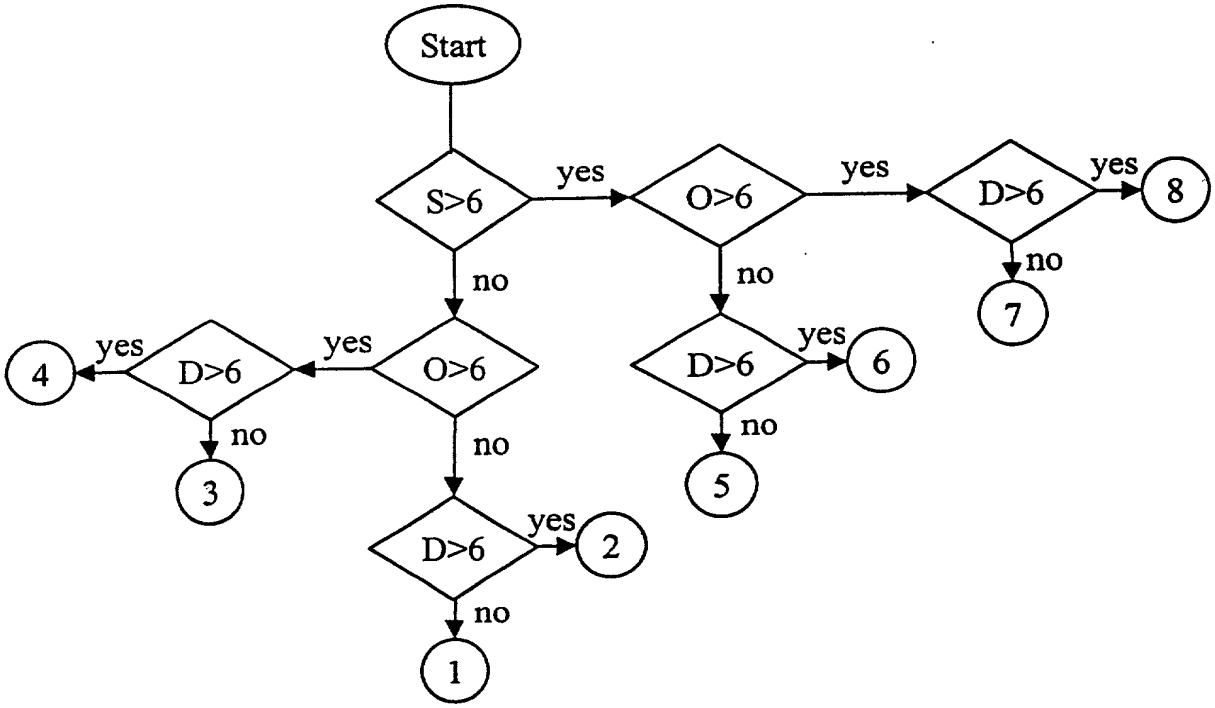
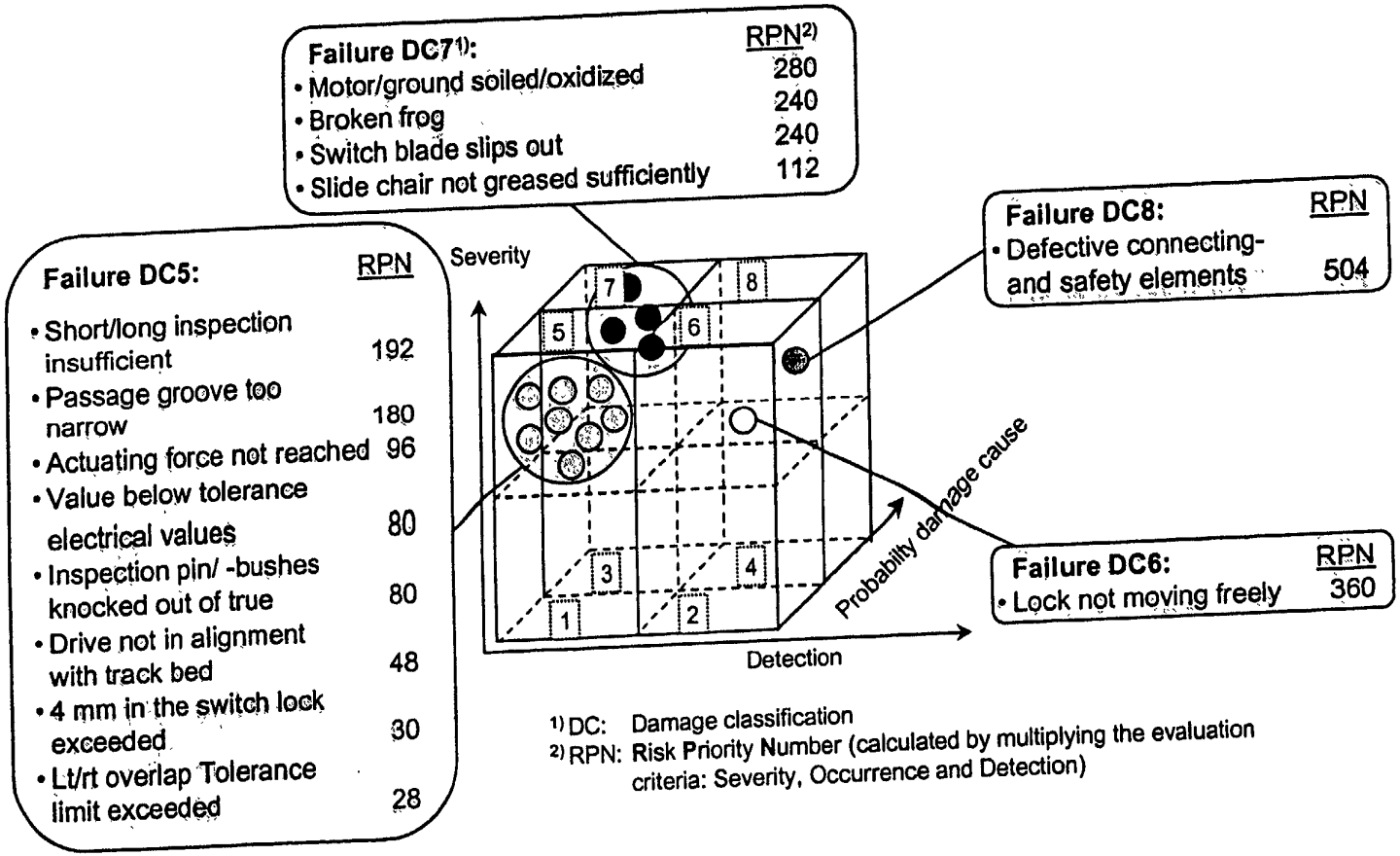

Start
S>6
yes
no
O>6
yes
no
D>6
yes
no
8
7
D>6
yes
no
6
5
O>6
yes
no
D>6
yes
no
4
3
D>6
yes
no
2
1

FIG. 13



[1] DC: Damage classification
[2] RPN: Risk Priority Number (calculated by multiplying the evaluation criteria: Severity, Occurrence and Detection)

FIG. 14

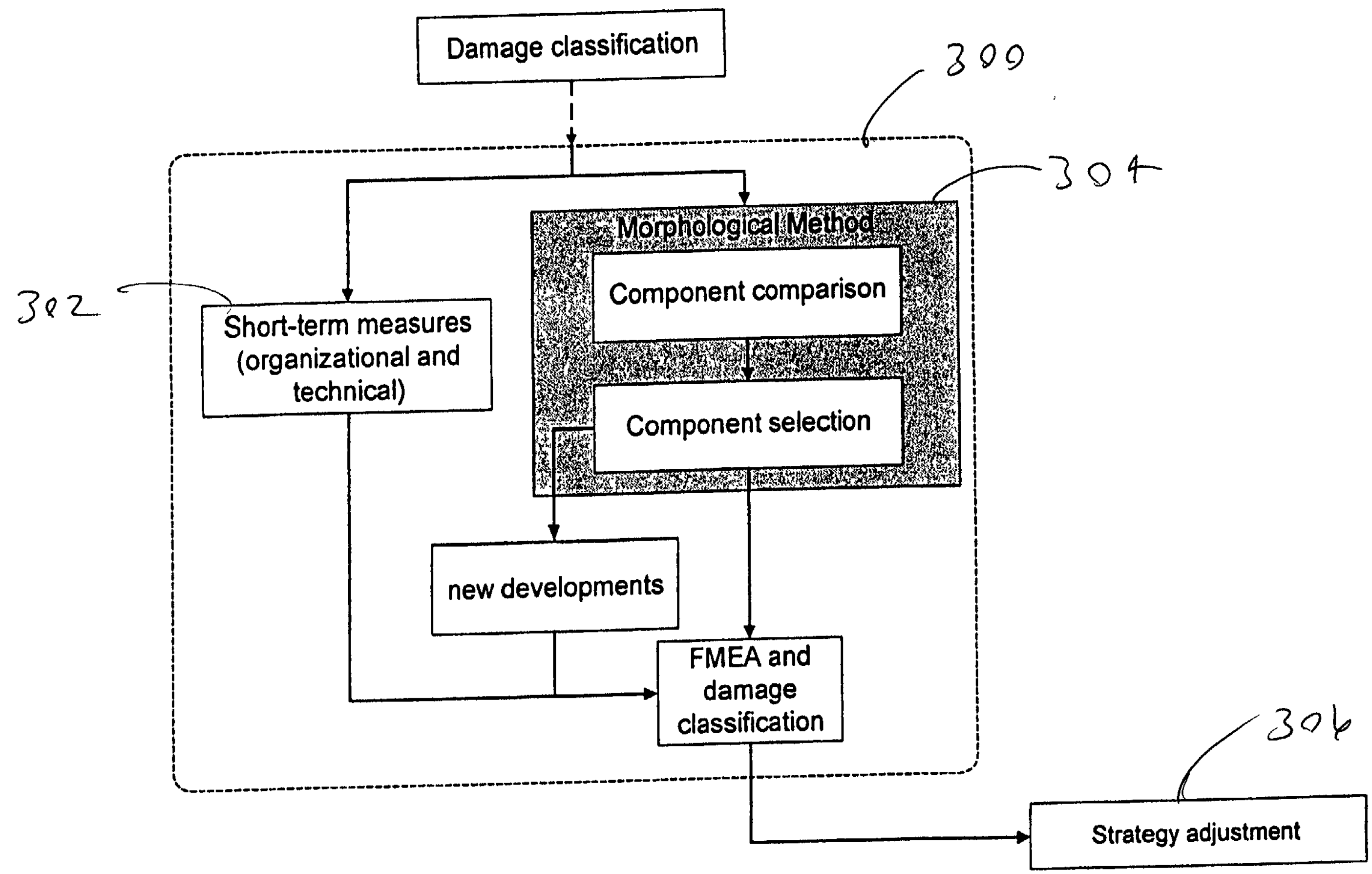


FIG. 15

No.	Equip-ment	Problem	Measure Proposal from FMEA Workshop	In charge	Date	Comments
1.1	Switch	Stiffness of switch in interlock or due to inadequately lubricated slide chairs	Equipping of the switches with latch fastenings and roller slide chairs in critical systems	Mr. Schmitz	06/2001	Budget of DM 50,000 authorized by management
1.2	Switch	Defective connecting and locking elements	Use self-locking transmission and connecting elements	Mr. Schulz	12/2001	Only No. 237 screws to be used

FIG. 16

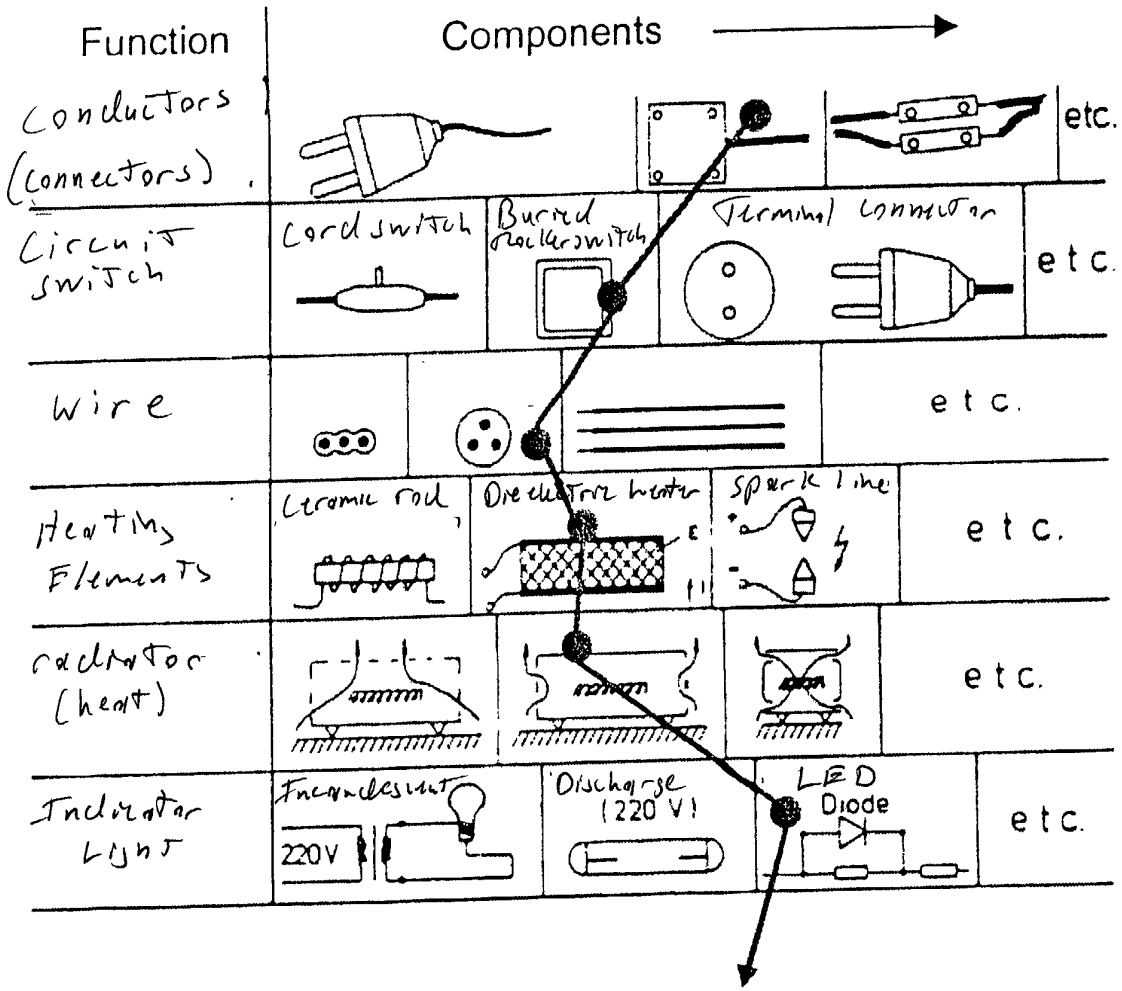


FIG. 17

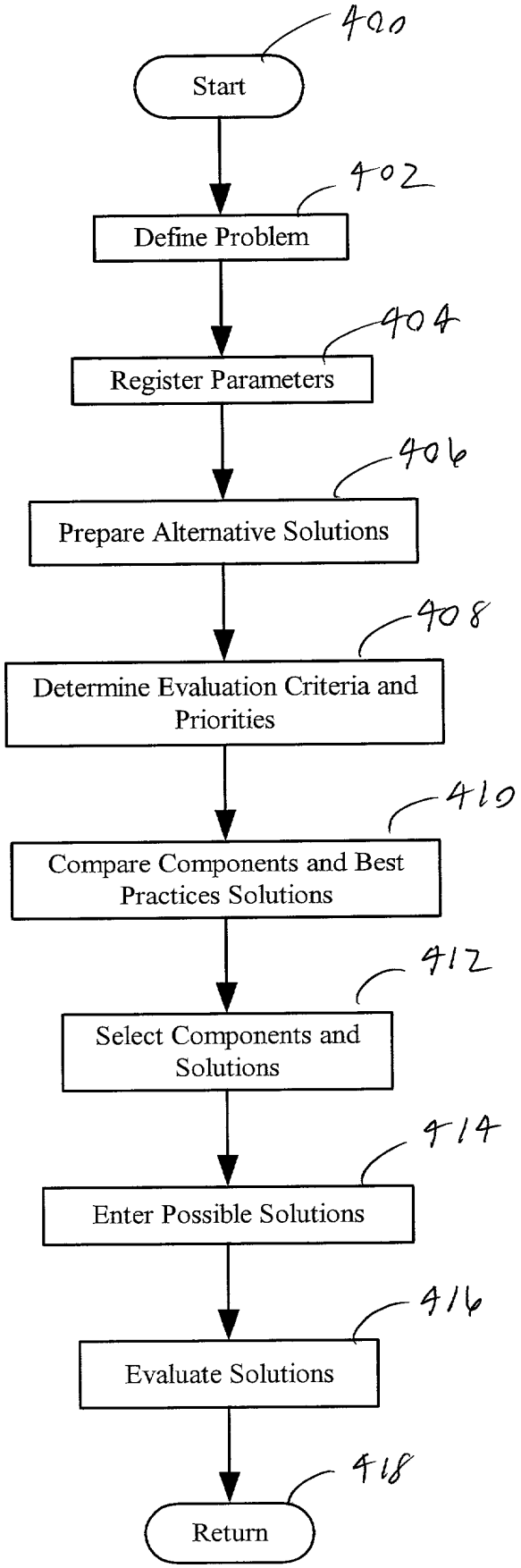

400
Start
402
Define Problem
404
Register Parameters
406
Prepare Alternative Solutions
408
Determine Evaluation Criteria and Priorities
410
Compare Components and Best Practices Solutions
412
Select Components and Solutions
414
Enter Possible Solutions
416
Evaluate Solutions
418
Return

FIG. 18

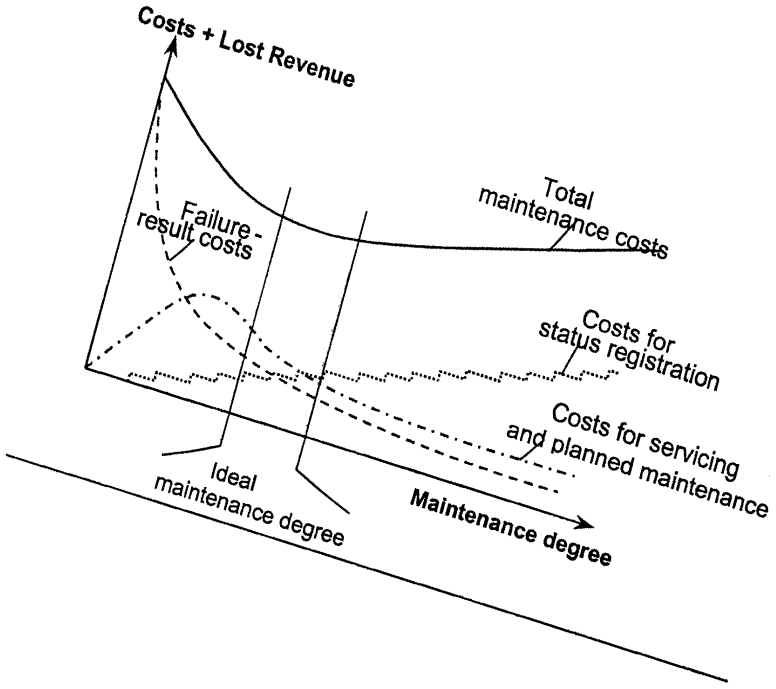
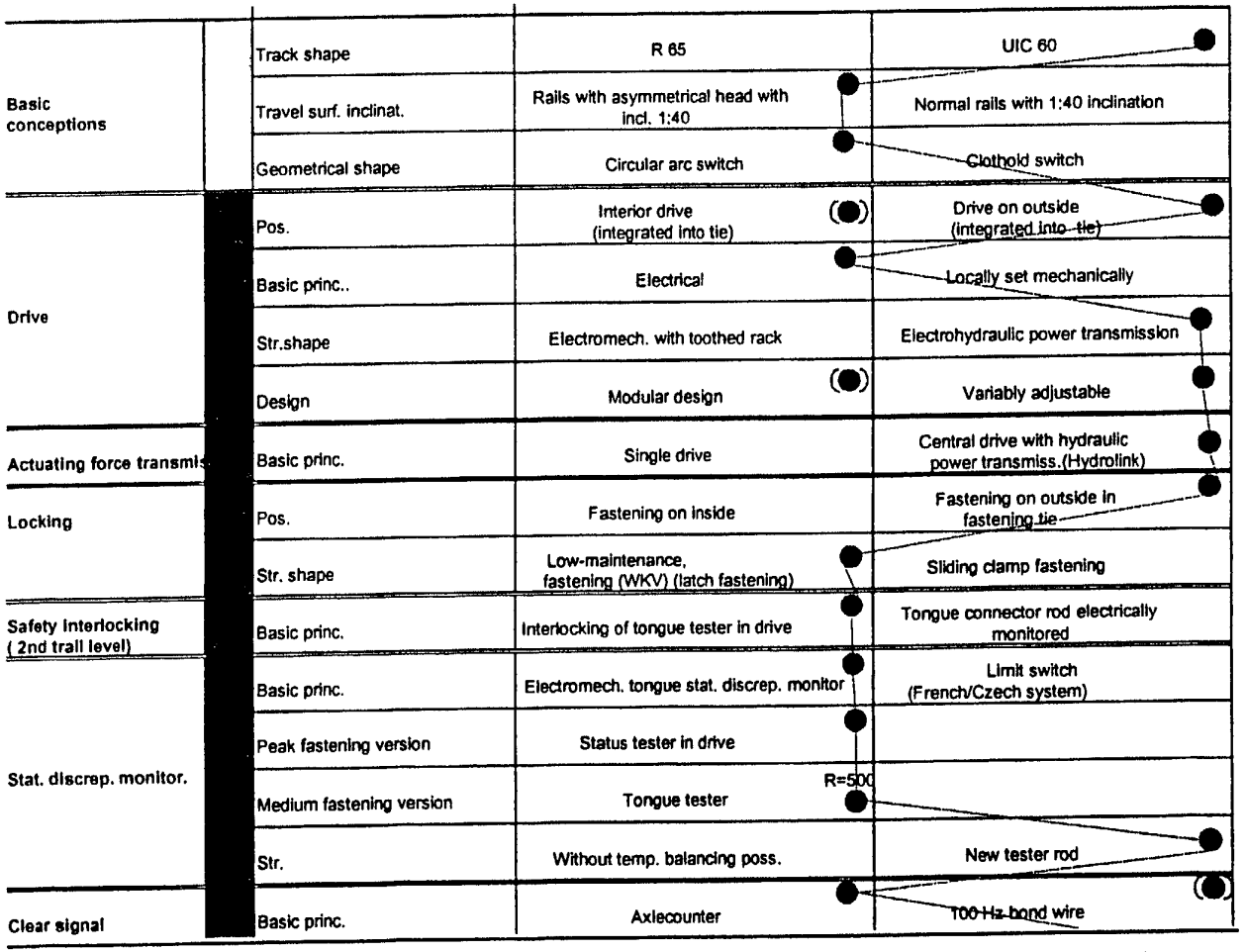

Costs + Lost Revenue
Total
maintenance costs
Failure -
result costs
Costs for
status registration
Costs for servicing
and planned maintenance
Ideal
maintenance degree
Maintenance degree

FIG. 19

FIG. 20


Basic conceptions
Track shape
R 65
UIC 60
Travel surf. inclinat.
Rails with asymmetrical head with incl. 1:40
Normal rails with 1:40 inclination
Geometrical shape
Circular arc switch
Clothoid switch
Drive
Pos.
Interior drive (integrated into tie)
Drive on outside (integrated into tie)
Basic princ..
Electrical
Locally set mechanically
Str.shape
Electromech. with toothed rack
Electrohydraulic power transmission
Design
Modular design
Variably adjustable
Actuating force transmis
Basic princ.
Single drive
Central drive with hydraulic power transmiss.(Hydrolink)
Locking
Pos.
Fastening on inside
Fastening on outside in fastening tie
Str. shape
Low-maintenance, fastening (WKV) (latch fastening)
Sliding clamp fastening
Safety interlocking (2nd trail level)
Basic princ.
Interlocking of tongue tester in drive
Tongue connector rod electrically monitored
Stat. discrep. monitor.
Basic princ.
Electromech. tongue stat. discrep. monitor
Limit switch (French/Czech system)
Peak fastening version
Status tester in drive
Medium fastening version
Tongue tester
R=500
Str.
Without temp. balancing poss.
New tester rod
Clear signal
Basic princ.
Axlecounter
100 Hz bond wire

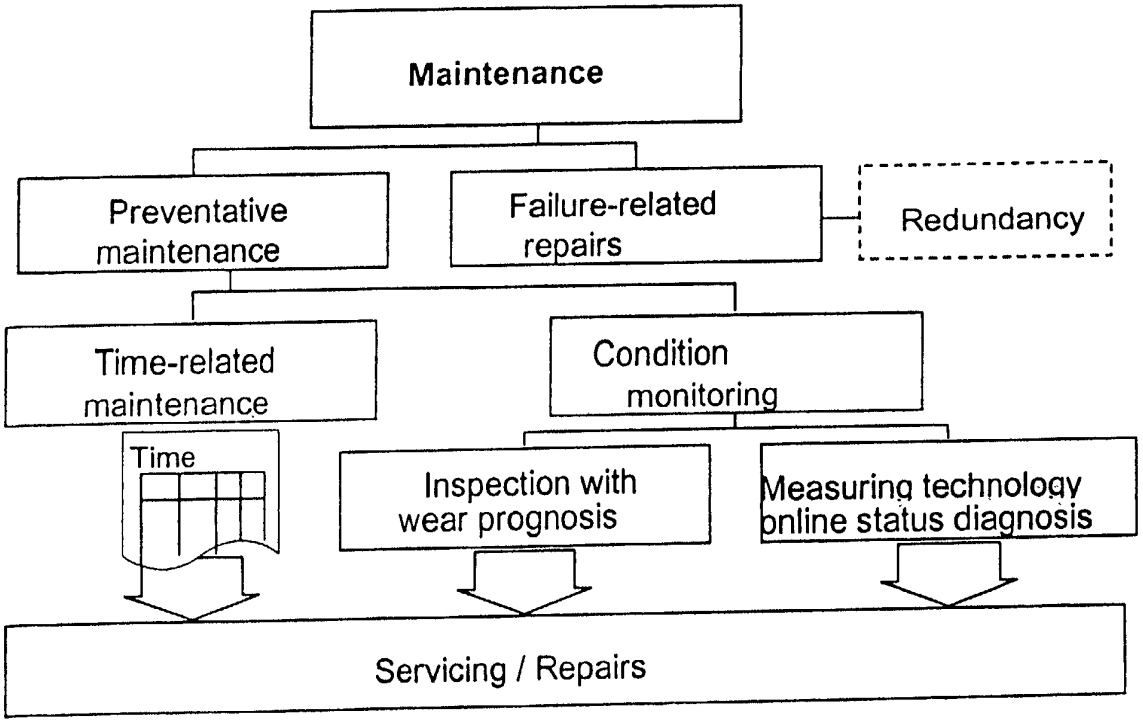

Maintenance
Preventative maintenance
Failure-related repairs
Redundancy
Time-related maintenance
Condition monitoring
Time
Inspection with wear prognosis
Measuring technology online status diagnosis
Servicing / Repairs

FIG. 21

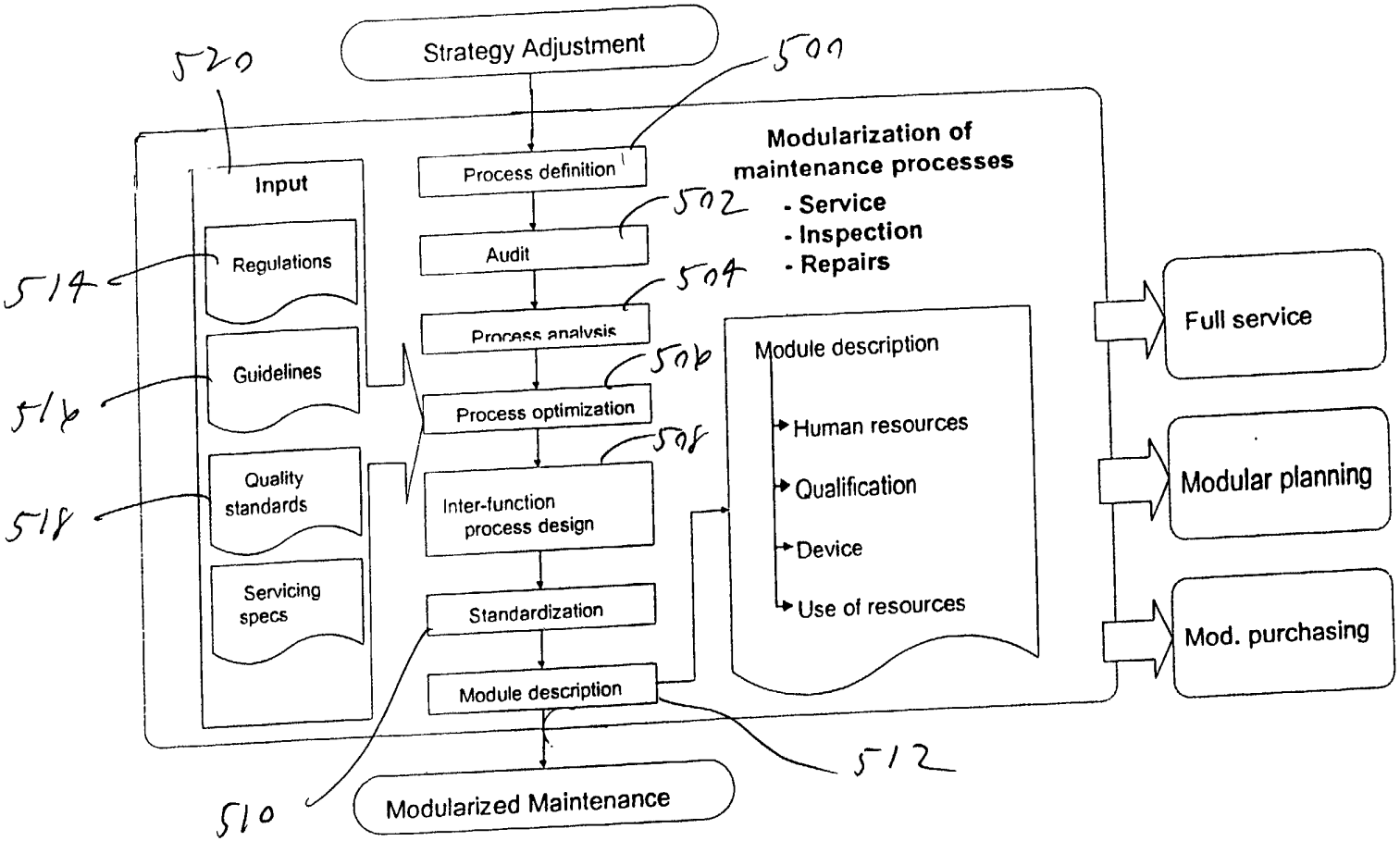

520
Strategy Adjustment
501
Modularization of maintenance processes
- Service
- Inspection
- Repairs
Input
Process definition
502
Audit
504
Process analysis
506
Process optimization
508
Inter-function process design
Standardization
Module description
514
Regulations
516
Guidelines
518
Quality standards
Servicing specs
Module description
Human resources
Qualification
Device
Use of resources
Full service
Modular planning
Mod. purchasing
512
510
Modularized Maintenance

FIG. 22

Audit Sheet

Name _____ Weather _____ Date: _____

module mark _____ Network _____

Module description _____

Worker qualification	Activity	Progress	Cell	Core Time	Preparatory Time	Travel Time	Waiting Time	Personal Time	Idle Time	Lost Time	Limiting factors	Module	remarks ...

FIG. 23

Switches

Module number	Module	Module contents	Machines, devices, additional personnel	Module time / unit (Format minute)	Number of employees / qualifications	Time limits acc. to load codes					Bill of quantities
						CST 91 Tw 1 low	CST 92 Tw 1 normal	CST 92 Tw 2 normal	CST 93 Tw 3 high	CST 93 Tw 4 high	
INWE 300.1.93.3 4	Switch 190 to 300 electr. (Time limit 1) [St]	Single switch with electric drive radius 190 to 300 m maintenance, inspection, functional check and general details acc. to DS 892.03 Appendix 02 Appendix 03		11 Mai	1 Wmech (Certif. acc. to 821.2005) 1 Wmech				1	1	Single switch 1 electric drive Iso joints, track connection cables, meshing and grounding 1 peak fastening switch heating system
INWE 300.2 92 1 2 93 3 4	Switch 190 to 300 electr. (Time limit 2) [St]	Single switch with electric drive radius 190 to 300 m maintenance, inspection, functional check and general details acc. to DS 892 03 Appendix 02 Appendix 03		14	1 Wmech (Certif acc to 821.2005) 1 Wmech		2	2	2	2	Single switch electric drive Iso joints, track connection cables, meshing and grounding 1 peak fastening switch heating system
INWE 300.3.93 3 4+A1	Switch 190 to 300 electr. (Time limit 3) [St]	Single switch with electric drive radius 190 to 300 m maintenance, inspection, functional test and general details acc to DS 892.03 Appendix 02 Appendix 03 Tw acc. to 821 2005	Trackway measuring instruments	51.5	1 M tw od. 1 MA with proven 2-year testing work of measuring instrument (821.2005) 1 Wmech (Certif acc. to 821.2005) 1 Wmech				3	3	Single switch 1 electric drive Iso joints, track connection cables, meshing and grounding 1 peak fastening switch heating system

FIG. 24

Components	TPM	RCM	Modular-ization
Focus on machines	No	Yes	Yes
Creation of inspection methods for the equipment	No	Yes	Yes
Individual determination of the maintenance strategy	No	Yes	Yes
Tips on the use of diagnostic methods	Yes	Yes	Yes
Creation of spare part management	No	General tips	Yes
Instructions on inclusion of sub-contractors	Yes	No	Yes
Tips for constructive modification	Yes	Yes	Yes
Instructions for redundancy formation	No	Yes	Yes
Tips for the speedy replacement of construction groups	Yes	Yes	Yes
Description of maintenance tasks	Inspection + service (not incl. repairs)	Inspection + service (not incl. repairs)	Inspection + service (not incl. repairs)
Tips for increased productivity	No	No	Yes
Determination of required time	No	No	Yes
Determination of implementation responsibility	Yes	Yes	Yes
Determination of implementation intervals	Yes	Yes	Yes
Employee instruction	Yes	Yes	Yes
Further training of employees	Yes	Yes	Yes
Adaptation of construction organization	No	no	yes

FIG. 25